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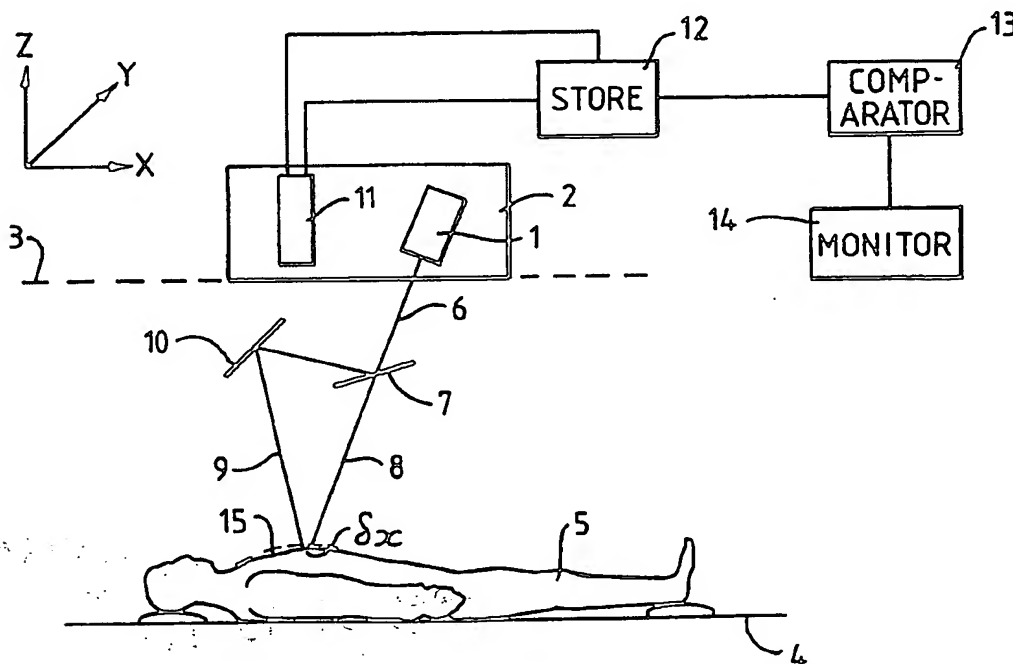
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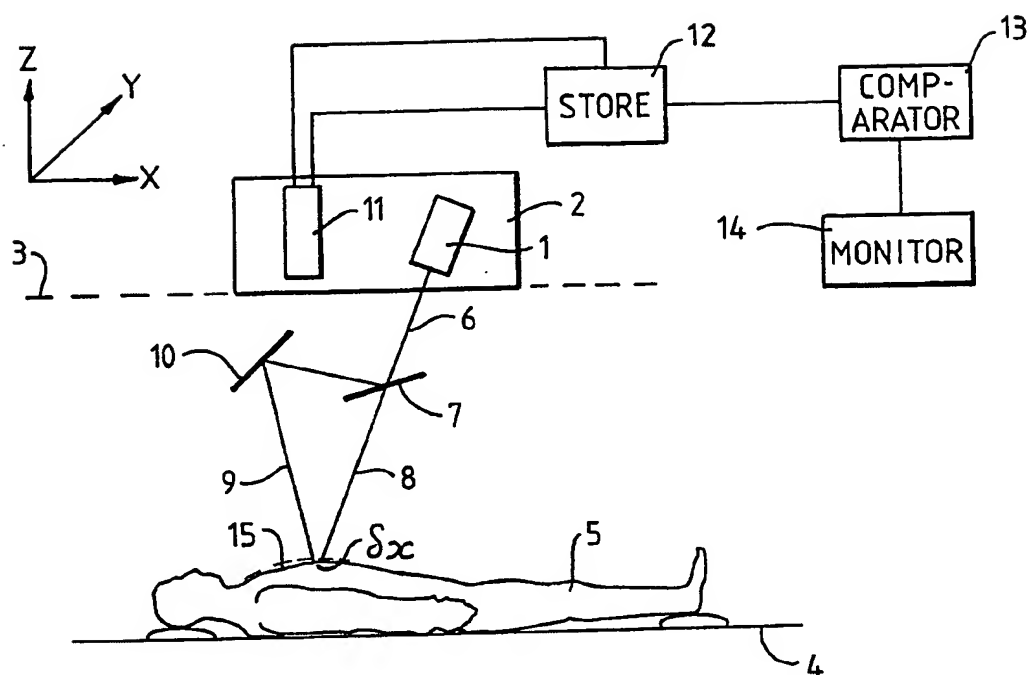
(54) Displacement monitoring system using two light beams

(57) A method of and apparatus for detecting movements of a surface (15) of a body (5) in which two beams of light (8, 9) are directed at the body (5) at an angle to each other and changes in their separation (δx) where they impinge on the body are monitored to detect changes in the position of the body (5) relative to a reference plane (3). The system may comprise of a single laser (1) arranged to supply two infra-red radiation beams (8, 9) which can be modulated to avoid interference. The system may be scanned in two dimensions within the plane normal to that of the two radiation beams and the signals processed for assessing relative displacements.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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The Monitoring of Displacements

5 The present invention relates to the monitoring of
displacements and more particularly to monitoring
displacements due to changes in physical parameters such
as the size, configuration or position of a solid body.

10 A number of circumstances can arise in which it is
necessary to monitor displacements due to changes in the
size, configuration or position of a solid body. For
example, one may wish to monitor deflections of a beam or
the wall of a pressure vessel under load, or the
breathing or position of a sleeping or otherwise
unconscious person.

15 Many methods exist for carrying out such an
operation ranging from contact probes to interferometric
methods. It is an object of the present invention to
provide a method of, and apparatus for, monitoring
20 displacements of a body, which are non-contacting and
unobtrusive.

25 According to the invention there is provided a
method of monitoring displacements of a surface of a body
comprising the operations of establishing a reference
plane with respect to a body displacements of a surface
of which are to be monitored, directing two beams of
light at the body at an angle to each other, determining
the separation between the points at which the two beams
30 are incident upon the body and detecting temporal changes
in the separation of the two positions at which the beams
of light are incident upon the body thereby to monitor
displacements of the surface of the body.

35 Also according to the invention there is provided an
apparatus for monitoring displacements of an element of a

surface of a body, comprising means for producing two beams of light and projecting them at an angle to each other onto an element of a surface of a body displacements of which are to be monitored, means for measuring the separation between the positions on the body at which the two beams of light are incident to determine a measure of the distance between the element of the surface of the body and a reference plane associated with the body, means for detecting temporal changes in the separation between the positions at which the two beams of light are incident upon the element of the body to determine displacements of the element of the surface of the body and means for indicating the displacements of the surface of the body.

Preferably there is included means for repeatedly scanning the two beams of light over the surface of the body in a direction normal to the line joining the positions at which the two beams of light are incident upon the surface of the body, the scanning means being adapted to move in the said reference plane, means for storing data relating to the measurements made during one scan of the separation between the positions at which the two beams of light are incident upon the body, means for comparing the stored data with corresponding data acquired in a succeeding scan of the beams of light over the body and means for providing an indication of any differences between the compared data thereby to monitor displacements relating to the body.

Displacements relating to a body which can be monitored by the present invention include changes in the size, configuration or position of the body.

The invention will now be explained and described, by way of example, with reference to the accompanying

drawing which is a diagrammatic representation of an apparatus for monitoring the movements of the body of a sleeping person.

5 Referring to the drawing, a laser source 1 of infra
red radiation is mounted upon a carriage 2 which is
adapted to be moved, by means not shown, in a plane 3
(x,y) a distance z above a bed 4 upon which is a person
5. The output beam 6 from the laser 1 is divided by a
10 beam splitter 7 and formed into two beams 8 and 9. The
beam 8 is directed directly at the person 5 and the beam
9 is directed also at the person 5 by means of a mirror
10. The beams of light 8 and 9 are arranged to converge
at an angle θ , but to be separated by a distance δx
15 where they impinge upon the body of the person 5. A
position sensing detector 11 is arranged to observe the
position where the beams of light 8 and 9 are incident
upon the person 5 and produce data signals related
thereto. The data signal from the detector 11 are
20 applied to a store 12, a comparator 13, and thence to a
monitor 14. Also applied to the store 12 are signals
related to the position of the carriage 1 in the
reference plane 3.

25 The separation δx between the points where the beams
8 and 9 impinge on the body of the person 5 is a function
of the angle θ and the distance z between the upper
surface 15 of the body of the person 5 and the reference
plane 3.

30 Assuming the scan of the carriage is regular, the
co-ordinates (x,y) of any given point 0 in a complete
scan of the carriage 2 in the (xy) plane 3 between limits
x = 0 \rightarrow X and y = 0 \rightarrow Y can be deduced from measurements
35 of the time which has elapsed from the beginning of a
scan only, as follows:-

let t_1 = the time taken for each complete scan of
the beams of both 8 and 9 in the y-
direction,
 δt = the time taken for the beams 8 and 9 to
reach 0 in the y-scan in which it occurs,
 t_2 = the time taken from the beginning of the
total scan for the beams 8 and 9 to reach
the position 0,
 n = the number of complete y-scans to reach
the position 0,
 T = the total time taken to complete a scan
field ($x = 0 \rightarrow X$, $y = 0 \rightarrow Y$), and
 N = the total number of y-scans in a scan
field.

We have $t_2 = (n t_1 + \delta t)$, therefore $\delta t = t_2 - nt$,

$$\text{and } x = \left[\frac{n}{N} \right] X, y = \left[\delta \frac{t}{t_1} \right] Y$$

As the person 5 breathes and his chest rises and
falls, the separation δx will change in a regular way.
Changes in the condition of the person 5 can be monitored
by storing in the store 12 the changes in the separation
 δx which occur during one complete breathing cycle and
comparing the stored data with later acquired data.
Movement of the body of the person 5 can be monitored by
scanning the carriage 2 in the y-direction, storing data
related to the changes in δx as the light beams 8 and 9
are scanned over the body of the patient 5, and comparing
data from one scan with data from a succeeding scan.
Whole body movement can be detected by scanning the
carriage 2 in the x-direction as well as the y-direction
and carrying out similar storage and comparison
operations as before.

In order to distinguish between the image spots of

the beams 8 and 9 and to avoid possible extraneous interference effects one or both of the beams 8 and 9 can be modulated.

- 5 When the body being monitored is a human being, as described above, it is preferable that the laser 1 is a low powered infra-red laser. It may be operated in either a continuous or pulsed mode.

10 .

Claims

1. A method of monitoring displacements of a surface of a body comprising the operations of establishing a reference plane with respect to a body displacements of a surface of which are to be monitored, directing two beams of light at the body at an angle to each other, determining the separation between the points at which the two beams are incident upon the body and detecting temporal changes in the separation of the two positions at which the beams of light are incident upon the body thereby to monitor displacements of the surface of the body.
2. A method according to Claim 1 wherein the displacements of the surface of the body are due to changes in the size, configuration or position of the body.
3. An apparatus for monitoring displacements of an element of a surface of a body, comprising means for producing two beams of light and projecting them at an angle to each other onto an element of a surface of a body displacements of which are to be monitored, means for measuring the separation between the positions on the body at which the two beams of light are incident to determine a measure of the distance between the element of the surface of the body and a reference plane associated with the body, means for detecting temporal changes in the separation between the positions at which the two beams of light are incident upon the element of the body to determine displacements of the element of the surface of the body and means for indicating the displacements of the surface of the body.
4. Apparatus according to Claim 3 wherein there is

included means for repeatedly scanning the two beams of light over the surface of the body in a direction normal to a plane in which the two beams of light lie, the scanning means being adapted to move in the said
5 reference plane, means for storing data relating to measurements made during one scan of changes in the separation between the positions at which the beams of light are incident upon the body, means for comparing the
10 stored data with corresponding data acquired in a succeeding scan of the beams of light over the body and means for providing an indication of any differences between the compared data sets thereby to monitor displacements of the surface of the body.

15 5. An apparatus according to Claim 4 wherein the scanning means is adapted to raster scan the two beams of light over an area of the body extending perpendicularly to the first direction of scan of the two beams of light over the surface of the body.

20 6. An apparatus according to any of Claims 3 to 5 wherein the two beams of light are derived from a single source.

25 7. An apparatus according to any of Claims 3 to 6 wherein at least one of the beams of light is modulated thereby to prevent optical interference between the two beams of light.

30 8. An apparatus according to any of Claims 3 to 7 wherein the two beams of light have a wavelength in the infra-red region of the electromagnetic spectrum.

35 9. An apparatus according to any of Claims 3 to 8 wherein the beams of light are beams of laser radiation.

10. A method for monitoring displacements of a surface of a body substantially as hereinbefore described and with reference to the accompanying drawing.

5 11. An apparatus for monitoring displacements of a surface of a body substantially as hereinbefore described and with reference to the accompanying drawing.

Category	Identity of document and relevant passages	Relevant to claim(s)

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